

WHAT IS CLAIMED IS:

1. In a system in which a boring tool is moved through the ground in a region, an arrangement for tracking the position and/or guiding the boring tool as it moves through the ground, said arrangement comprising:

(a) means located within said boring tool for transmitting an electromagnetic field;

(b) one or more detector means for receiving said electromagnetic field, each detector means having an electromagnetic field receiving antenna assembly including at least one antenna for measuring at least one component of the intensity of said electromagnetic field, each detector being located at a fixed position with its antenna at a particular orientation within said region, but not necessarily along an intended path of movement of said boring tool;

(c) means for determining certain initial conditions prior to drilling which include the positions of said detectors in said region, the particular orientation of the antenna associated with each detector provided and an initial position and orientation of the boring tool;

(d) processing means for using at least one measured component of the intensity of said electromagnetic field, which is obtained using said detector or detectors after the boring tool moves a distance along said path, in determining, at least to an approximation, the position of the boring tool after moving said distance; and

(e) a mapping tool having means for transmitting an electromagnetic field and a tilt sensing mechanism, said mapping tool being used to determine the positions and orientations of all of said antennas for each detector within said region.

2. In a system in which a boring tool is moved through the ground in a region, an arrangement for tracking the position and/or guiding the boring tool as it moves through the ground, said arrangement comprising:

(a) means located within said boring tool for transmitting an electromagnetic field;

(b) two or more detector means for receiving said electromagnetic field, each detector means having an electromagnetic field receiving antenna assembly including at least one antenna such that the detector means, in combination, measure at least five different components of the intensity of said electromagnetic field, each detector being located at a fixed position with its antenna or antennas at a particular orientation within said region, but not necessarily along an intended path of movement of said boring tool;

(c) mapping tool means for use in determining certain initial conditions prior to drilling including the positions of said detectors in said region and the particular orientations of the antenna or antennas associated with each detector provided; and

(d) processing means for using the five measured components of the intensity of said electromagnetic field, which are obtained using said detector or detectors after the boring tool moves a distance along said path, in determining the position and orientation of the boring tool after moving said distance.

3. The arrangement of Claim 2 wherein two detector means are provided and the antenna assembly of each detector means includes three antennas which are arranged orthogonally with one another such that three magnetic field components are measured by each detector means for a total of six intensity components of said electromagnetic field.

4. The arrangement of Claim 3 wherein said processing means includes means for determining a signal strength of said electromagnetic field at the boring tool in addition to determining the position of said boring tool.

5. The arrangement of Claim 2 wherein said mapping tool means includes a magnetometer for determining the magnetic orientation of said antennas within said detector means.

6. The arrangement of Claim 2 wherein said mapping tool means includes a tilt meter for determining the orientation of said antennas within said detector means with respect to a horizontal plane.

7. The arrangement of Claim 2 wherein said mapping tool means and each said detector means are cooperatively configured such that the mapping tool means can be placed on each detector means in a predetermined way such that a specific positional relationship is maintained between the mapping tool means and the detector means on which it is positioned whereby measurements may be taken by the mapping tool relating to that detector means.

8. The arrangement of Claim 2 wherein said mapping tool means includes means for transmitting an electromagnetic setup signal for receipt by said detector means whereby the positions of the detector means may be established in a predetermined way.

9. The arrangement of Claim 2 wherein said mapping tool means includes means for transmitting an electromagnetic setup signal for receipt by said detector means such that at least five electromagnetic setup components are produced whereby the position and orientation of the mapping tool may be determined by said processing means.

10. The arrangement of Claim 9 wherein said system includes means for plotting an intended course for said boring tool by positioning said mapping tool at points along said intended course and determining the positions of these points by measuring said electromagnetic setup components at each said point.